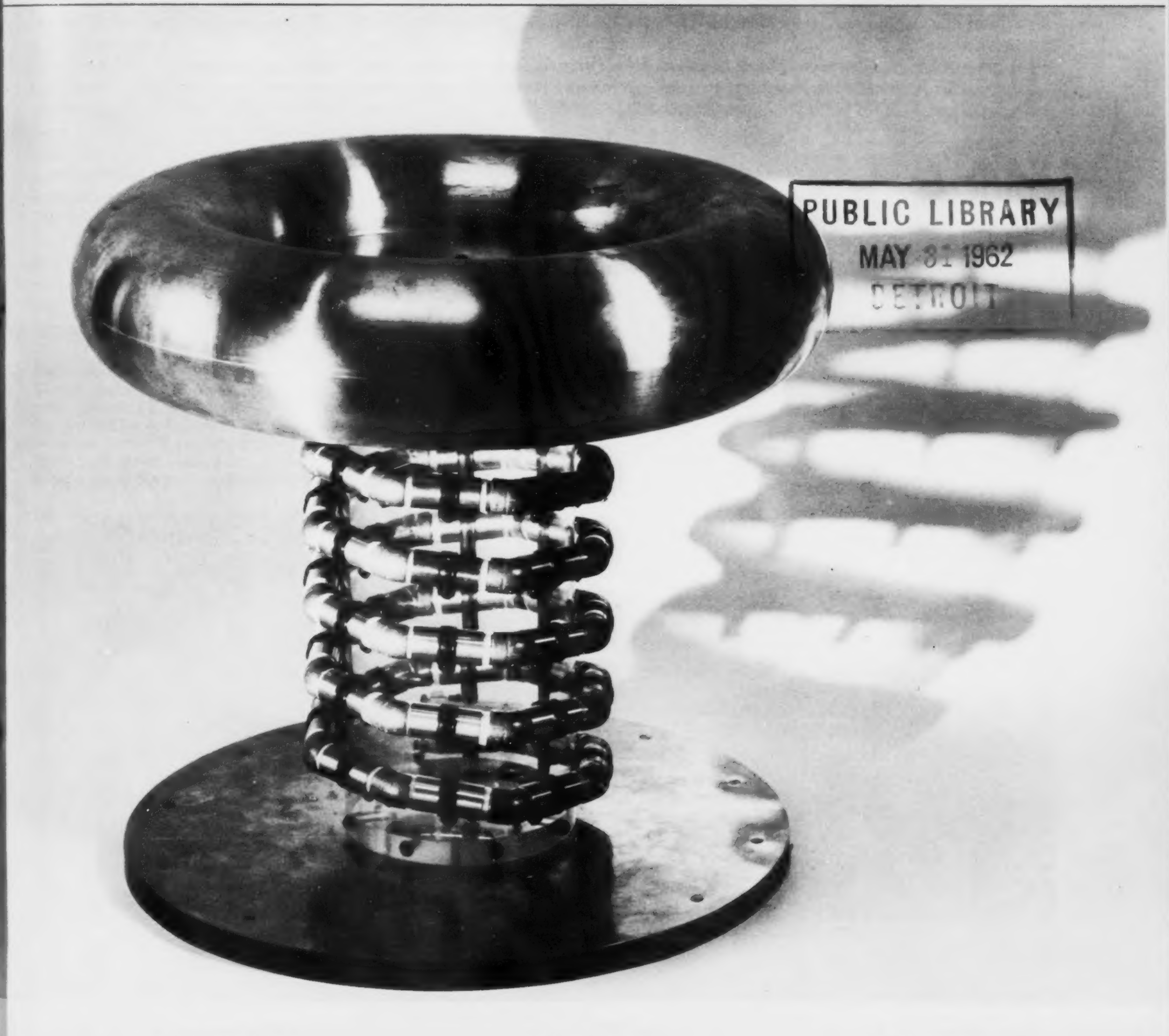
U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Technical News

BULLETIN



VOLUME 46 MAY 1962 NUMBER 5

U.S. DEPARTMENT OF COMMERCE LUTHER H. HODGES, Secretary

NATIONAL BUREAU OF STANDARDS A. V. ASTIN, Director

NATIONAL BUREAU OF STANDARDS Technical News BULLETIN

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Subscription price, domestic $1.50 a year; 75 cents additional for foreign mailing; single copy, 15 cents. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (June 19, 1961).

May 1962 Issued Monthly Vol. 46, No. 5

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COVER: A highly stable shielded resistor designed and constructed at the Bureau for use in the very precise measurement of high voltages. It has been found suitable for measuring d-c voltage up to 100 kv. It will serve as a standard for evaluating other high-voltage resistors, and for standardizing voltage dividers and electrostatic voltmeters. (See "Shielded Standard Resistor," p. 70).

UNITED STATES AND CANADIAN

Free-Air Ionization Chambers

COMPARED

FREE-AIR IONIZATION chambers are used by many nations as the standard instruments for measuring X- and gamma-ray exposure dose rates. A direct comparison of the standard free-air ionization chambers of the National Research Council of Canada and the National Bureau of Standards [1] has shown that the average of the ratios of exposure dose rate measurements made by these two instruments differs from unity by only 0.3 percent. This comparison, made with moderately filtered X-rays, was performed at the Bureau's Washington laboratories.

Each of the chambers consists of parallel metal plates, separated by an air gap, across which is applied a high potential.[2] The chamber is situated inside a shielding box having a diaphragm at the front for the admittance of radiation. Ions of a particular charge (resulting from the radiation) are swept by the applied potential from a defined length of the air to a collector plate which is connected to a circuit for the measurement of the ion current. The exposure dose rate in roentgens per unit time at the point of the diaphragm is then computed from the ion current, from the volume defined by the diaphragm diameter and the length of the collector plate, and from a number of correction factors. The chambers compared in this series of measurements were quite similar, although the Canadian instrument was somewhat larger.

A radiographic X-ray tube, to which were applied constant potentials of from 60 to 250 kv, was used to supply the radiation for the comparison. All runs were made with an inherent equivalent filter of approximately 4.5 mm of aluminum, to which could be added further aluminum or copper-aluminum filters as desired.

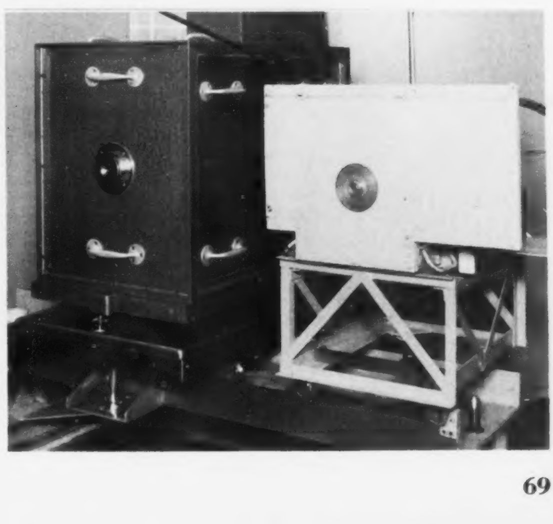
The chambers were placed on a frame-and-track and carefully alined. Comparisons were then made by alternately exposing the chambers to the X-ray beam. Five comparisons were made for most of the X-ray energies used.

Computations of exposure dose rate, including several small corrections, indicated that measurements made with these chambers are in close agreement over the energy range employed. The average of the NRC/NBS ratios was 1.003_2.

[1] *For further technical details, see* Comparison of United States and Canadian free-air ionization chambers, *by J. H. Aitken, L. DeLaVergne, W. H. Henry, and T. P. Loftus, British J. Radiol.*, **35**, 65 (*Jan. 1962*).

[2] *For a detailed description of free-air chambers, see* Design of free-air ionization chamber, *NBS Handb. 64, available from the Superintendent of Documents, U.S. Govt. Printing Office, Washington 25, D.C.,* (*20 cents*).

Left: **R. DeLaVergne positions the United States standard free-air ionization chamber within its shielding container. X-rays entering through the front of the container ionize the air within a known volume between the vertical aluminum plates of the chamber. A potential applied across the plates sweeps ions of a certain charge to the collector plate (*below left hand*) which is connected to a current-measuring circuit. The charge collected in a known period of time is used in computing a value in roentgens. *Right:* Canadian (*left*) and United States free-air ionization chambers were compared with moderately filtered X-rays over the range 60 to 250 kvcp. The chambers are positioned on railborne carriages to permit alternate exposure to the X-ray beam.**



SHIELDED STANDARD RESISTOR

for Accurate High-Voltage Measurements

A HIGHLY STABLE shielded resistor for use in precise measurement of high voltages has been designed by J. H. Park [1] of the high-voltage laboratory. The design minimizes resistance changes due to heating, current leakage, and corona discharges. One resistor of this type has already been constructed and found suitable for accurately measuring d-c voltages up to 100 kv. It will serve as a standard for evaluating other high-voltage resistors to be used for calibration purposes at other laboratories and for standardizing voltage dividers and electrostatic voltmeters.

The temperature coefficient of the resistor is estimated to be not greater than 0.4 ppm/°C, as compared with 100 ppm/°C for a resistor of an earlier, similar design. Corona and leakage errors determined using recently improved measuring techniques were found to be less than 10 ppm at 50 kv and less than 20 ppm at 100 kv.

An unusual feature of the resistor is that it is made up of a large number of individually shielded 1-megohm resistors which are connected in series and arranged to form a vertical helix between a ground plate and a high-voltage electrode. Brass shields completely enclose each resistor and prevent formation of corona at the surface of the resistance coil no matter how high the potential of the shield is above ground.

The high-voltage electrode is a special "hat" type that gives uniform gradients from the top of the resistor to ground. An advantage of this arrangement is that similar resistors can be stacked on one another and connected in series to measure higher voltages. The feasibility of such stacking has been indicated by the results of corona measurements. Exact accuracy limits attainable at voltages above 100 kv have not yet been ascertained.

Highly stable shielded standard resistor designed and constructed for use in accurate high-voltage d-c measurements. J. L. Mills connects the high-voltage electrode of the resistor to a 100-kv d-c power supply.

Accurate measurements of d-c voltages at values above 10 v are nearly always dependent upon a resistive voltage divider which consists of a high resistance, R_1, in series with a low resistance, R_2. The voltage to be measured is connected across the series combination with R_2 at the ground end. The divider ratio, $(R_1+R_2)/R_2$, is chosen to give about a 1-v drop across R_2, which can then be measured with a null potentiometer. This is the well-known "volt-box" method, and tapped resistors or volt boxes are readily available for voltages up to at least 1,500 v. The only difficulty encountered in extending this method to higher voltages is the problem of designing a high-voltage resistor having an effective value that does not change with voltage.

A change in effective resistance with voltage may be due to any one of three factors or to any combination thereof. These factors are: (1) heating of the resistance wire due to the I^2R loss—the magnitude of this change will depend upon the temperature coefficient of the entire resistor; (2) current leakage through the volume or over the surface of the insulation used to support the resistor—such leakage usually increases with voltage and, in effect, decreases the total resistance; (3) corona discharges which may appear at locations of high gradient along the resistor as the voltage is increased—in effect, these "leak" part of the resistor current to ground.

The heating effect can be quite troublesome unless the overall temperature coefficient is very low. However, since a high-voltage resistor is most conveniently made by connecting a large number of 1-megohm units in series, the temperature coefficient can be reduced to a negligible minimum by choosing some resistors with positive temperature coefficients and others with negative coefficients. This choice can be made readily if a large number of 1-megohm units made up of wire of one of a number of special alloys are available and their temperature coefficients have been measured.

Factors (2) and (3) cannot be measured and reduced to a low magnitude in any such simple manner. Thus, the primary design problem is to keep leakage and corona effects as low as possible. Also, some experimental method must be devised with which to detect any such effects when full voltage is applied to the complete resistor.

The Bureau's standard resistor is patterned after a similar resistor built at the Bureau in early 1955 and used as a standard for several years. In the earlier model, each 1-megohm resistor is mounted within brass shield caps that form a complete potential shield and

definitely fix the immediately surrounding voltage gradient (see diagram A). The present model employs shielded units containing two resistors matched to give a resulting temperature coefficient that is nearly zero (diagram B).

One-megohm units guaranteed to have a temperature coefficient less than 5 ppm/°C became available in 1960 as a result of improvements in manufacturing techniques and the use of special alloy wire of low temperature coefficient. A large number of these were ordered, and on delivery their temperature coefficients were determined by measurements at three or more temperatures between 20 and 44 °C. All were well within the 5 ppm/°C limit—also, some resistors increased and others decreased with rising temperature and, in general, the change was proportional to temperature. Thus it was possible to choose matched pairs of these resistors with nearly zero average temperature coefficient. By connecting such matched pairs in series, a high-voltage resistor having nearly zero change with tempearture was made.

Construction

The same helical type of construction as that of the earlier model was used for this resistor, but a new technique was devised for making the shields and connecting them in a helix. Each shielded unit containing two resistors is assembled from brass parts, machined out of tubing, and a 45° brass elbow (diagram B). Eight of these units, fitted together, constitute a single turn of the helix. As in the earlier model, polyethylene sheet insulation is used between the overlapping brass shield caps around each resistor.

On the basis of preliminary tests, a 100-megohm resistor of 6¼ turns with a pitch of 2⅜ in. per turn was built. The pitch was chosen so as to prevent any possibility of corona between adjacent turns. The turns are fastened onto a 7-in. diam, 16½-in. long lucite tube using one nylon clamp and screw for each unit. The tube is mounted vertically between a brass ground plate and a high-voltage electrode. The circular helical shape maintains a uniform potential drop per turn along the lucite tube. The copper "hat" placed on top of the lucite tube serves to intercept electrostatic lines of force from objects at ground potential and to prevent concentration of such lines of force at the top turns of the resistor helix. Thus the gradient at the outside surface of the individual resistor caps is very nearly the same for units near the top as for those near the bottom, and the possibility of corona from the shield caps is greatly reduced or eliminated.

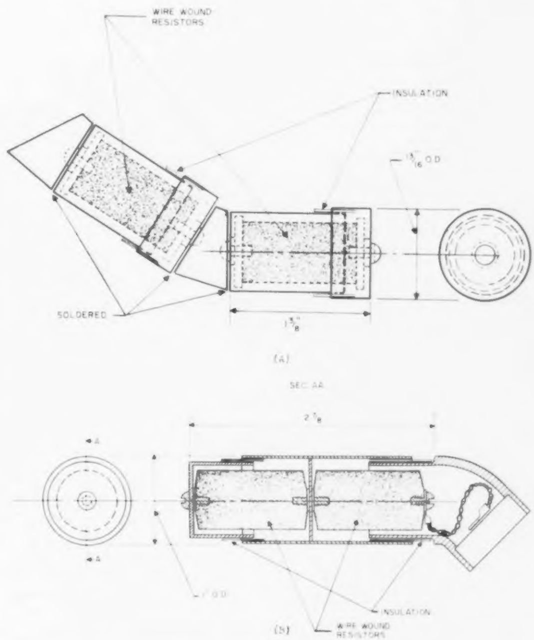
Evaluation

A number of tests were made on this configuration to determine possible corona and leakage errors. If there were any corona discharge or even "dark current" from the resistor at some point between the high-voltage electrode and the low-voltage lead, it would cause the current "out" at the low-voltage lead to be less than the current "in" at the high-voltage electrode. This difference would introduce a change in the value of effective resistance that is used in voltage measurements. Current leakage through or over the surface of any insulating supports would cause a similar type of error.

An experimental method was devised for measuring the current "out" and the current "in" at various voltages up to 100 kv. The accuracy of these measurements was estimated to be within 10 ppm at 50 kv and 20 ppm at 100 kv. Data on current "in" and "out" were obtained on several different days over a period of two months. Room temperature was 24 to 25 °C, and relative humidity varied from 37 to 50 percent. In all these tests, the current "out" was found to equal the current "in" to within the accuracy of measurement.

As a check for a possible error due to leakage of current via the lucite tube and the nylon clamps fastening the shielded units to the tube or via the polyethylene between shield caps, the resistances of several matched pairs of the 1-megohm units were measured after they had been mounted inside their shields and on the lucite tube. In every case the resistance thus measured agreed to within 10 ppm with the sum of the resistances of the individual units as measured before assembly.

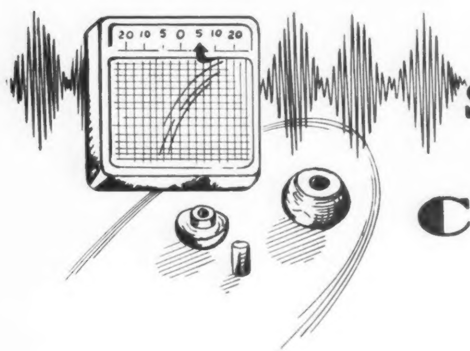
Corona tests on the high-voltage electrode were made up to 200 kv by using two 100-kv power supplies. The normally grounded brass plate was supported on ceramic insulators and connected to the minus-100-kv



Manner of mounting and shielding the individual one-megohm wire-wound resistors used in the shielded standard resistor. (*A*) Two 1-megohm resistors, mounted inside their shield caps, as used in first model of helical resistor. (*B*) Two-resistor shielded unit used in present model.

source. The high-voltage electrode was connected to the plus-100-kv source. For this test, the one hundred 1-megohm resistors were removed, but the same lucite tube was used to separate the electrode from the brass plate. Only a visual test could be made; therefore the setup was put inside a completely enclosed dark box large enough to house an observer as well. With a total voltage of 200 kv between brass plate and electrode, there was no visible or audible evidence of corona. Since this voltage was twice the maximum ever to be used with the resistors in place, it was concluded that there would be no corona current off the middle shield electrode when two units are stacked in series. If more than two units are to be stacked, further corona tests should be made and possibly larger shield electrodes than this one—22 in. in diameter—would be required.

[1] Special shielded resistor for high-voltage d-c measurements, *by J. H. Park, J. Research NBS* **66C** *(Eng. & Instr.), No. 1, 19 (1962).*



STANDARDS AND CALIBRATION

This Calibration Activities column is being initiated as a regular feature in the *Technical News Bulletin* to serve as a central source for information of interest to standards laboratories, both government and private, as well as other research and development laboratories which have a special interest in measurement and calibration.

The new column will contain items such as: changes in NBS calibration services as they appear in the Federal Register, including changes in the test fee schedules and new and discontinued calibration services; changes in the accuracies or ranges in measurement services; new labs at NBS; equipment developments at NBS; references to papers by NBS authors in outside journals dealing with measurement and calibration; news about standards laboratories activities, including organizations such as the National Conference of Standards Laboratories; sources of information outside NBS; technical information which does not lend itself to a formal paper; and announcements about NBS publications in process.

New Piston Gage

A new piston gage, recently put into operation, has extended the range and improved the accuracies of pressure measurements at the Bureau. The instrument utilizes the controlled clearance feature previously used. Operation at 120,000 psi has been highly successful, and a sensitivity of one part per million has been achieved at 50,000 psi. The fall rate of the freely rotating piston (0.079-in. diam.) was observed to be less than 0.001 in. per hour when the piston was floated on low viscosity oil at 50,000 psi.

The piston gage is being used for calibration purposes and will be used for the measurement of the freezing pressure (about 109,000 psi) of mercury at 0 °C. Apparatus for the mercury freezing point determination is now being assembled. An accuracy to within ±30 psi is being sought for this determination.

Calibration Publications

Paul P. B. Brooks, of the Resistance and Reactance Section, has prepared Monograph 39—*Calibration Procedures for Direct-Current Resistance Apparatus.* This Monograph describes in detail the apparatus and procedures used at NBS for the precise measurement of direct-current resistance when an accuracy of a few parts per million is required. It gives detailed information on the use of direct-reading ratio sets and universal ratio sets for calibrations of the highest accuracy, and should fill a real need for descriptions of the techniques and precautions in the use of these versatile measuring tools. The Monograph is available from the Superintendent of Documents, U.S. Govt. Printing Office, Washington 25, D.C., for 40¢

A General Description of DC Digital Voltmeters, by Carroll Stansbury of the Electrical Instruments Section, was published in the November 1961 issue of *Communications and Electronics* (American Institute of Electrical Engineers). The paper, which deals mainly with the basic principles of dc digital voltmeters, also discusses some of the problems of nomenclature, accuracy specifications, and reliability of these instruments, which, like dc potentiometers, can be used for very accurate measurements.

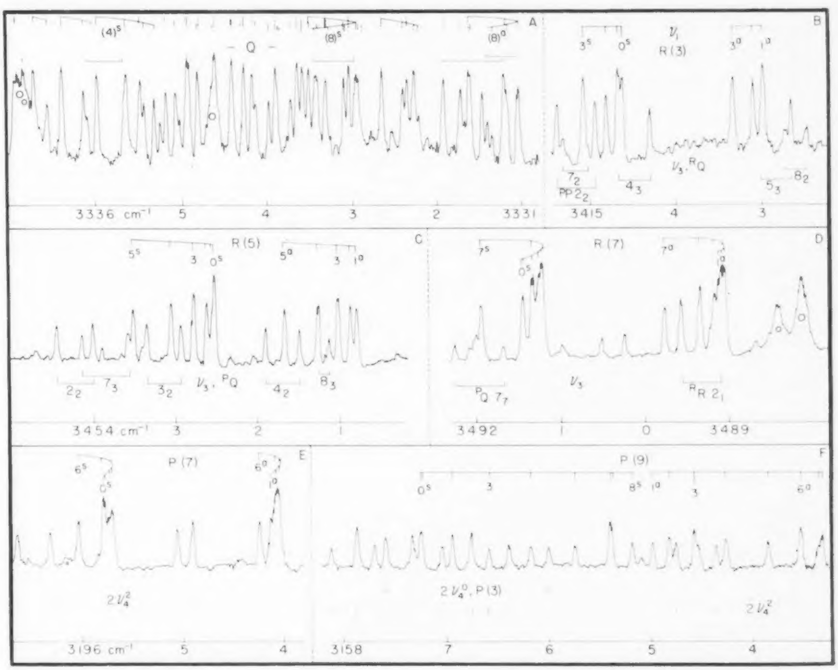
Research in Infrared Spectroscopy

BETTER STANDARDS and techniques for measuring infrared radiation and a more thorough understanding of molecular structure are resulting from a Bureau program of basic research in this wavelength region. An important part of the program is the determination of precise reference wavelengths, which are greatly needed because of the wide use of infrared spectra as a means of analysis. Results of the work also provide values of molecular constants used in chemical research to evaluate thermodynamic functions.

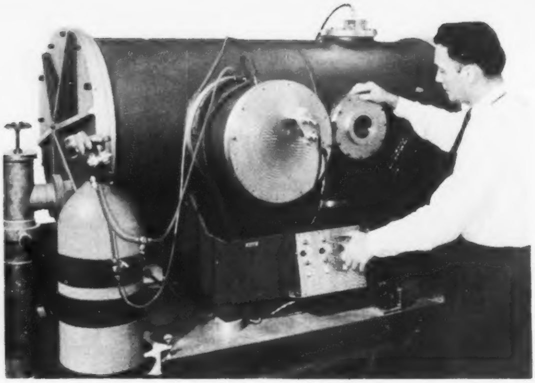
Several important projects have been undertaken for other government agencies. Under Air Force sponsorship, for example, laboratory measurements are being made of the emission spectra of hot gases. This work makes possible the determination of the higher energy levels of molecules. The measured positions of these lines can then be used to identify lines observed in long paths such as through the earth's atmosphere. Such identification is expected to lead to determination of average temperature and partial pressure of atmospheric constituents.

The Bureau also studies emittance properties of solids, which must be known for designing temperature control systems of satellites and space probes. In this work for Army Ordnance, the emissivities of gold, platinum, and aluminum have been measured in the infrared region, so that the heat losses from a satellite may be properly balanced.

A number of different types of spectrometers are employed for these various projects. Two high-resolution grating spectrometers with several interchangeable gratings are used in the wavelength region from 1 to 15 μ. One of these, designed by E. K. Plyler and L. R. Blaine of the infrared spectroscopy laboratory, has a resolution approaching 0.02 cm^{-1} in the region from 3 to 4 μ. Several small prism instruments are used in



Examples of spectra obtained with the high-resolution grating spectrometer. At upper left is the *Q*-branch of the 3-μ band of ammonia. The other traces show some of the rotational lines of this band observed at very slow scanning speeds.



L. R. Blaine adjusts the slit width of the vacuum grating spectrometer which he designed for use in the far infrared region. This instrument is used for measuring the long wavelength bands in crystals and semi-conductors and the torsional vibrations in halogenated molecules.

the region from 2 to 50 μ with prisms of lithium fluoride, sodium chloride, potassium bromide, calcium fluoride, cesium bromide, and cesium iodide. For measurements of spectra in the far infrared region (50 to 400 μ), a vacuum grating spectrometer designed by Blaine has been constructed.

The Bureau's spectroscopic research programs are broad and are aimed toward developing better methods and finding new applications. Until 1945, infrared prism spectrometry was limited to the spectral region from 2 to 25 μ. Then Bureau scientists under the direction of F. P. Phelps succeeded in growing crystals of cesium bromide and cesium iodide, thereby increasing the spectral range to 55 μ. More recently, an economical method was found for converting a prism instrument into a small grating spectrometer for measurements from 50 to 400 μ. Other studies have brought about an increase in the resolution of grating spectrometers to a very high level.

Although the infrared region of the electromagnetic spectrum has been known for about 160 years, the first infrared spectrometers which had any relation to the present types were not designed until about 1880. At that time, there was considerable activity in this area in Germany and in the United States, especially by S. P. Langley. One of Langley's spectrometers included rock-salt lenses as well as rock-salt prisms, and was considered the finest instrument in dispersion of any yet built.

Soon after Langley's original work, H. Rubens, Director of the Institute of Experimental Physics of the University of Berlin, began a series of investigations to improve methods of observing infrared spectra. He worked in the infrared spectrum to about 260μ. His studies of the spectral properties of materials, sources, and detectors laid the groundwork for all present-day far-infrared spectrometers.

In 1900, W. W. Coblentz began a career in infrared spectroscopy which has had a profound influence on the development and the use of infrared spectroscopy as a means of analysis and thus on its industrial applications. Dr. Coblentz, who was Chief of the Bureau's Radiometry Section from 1905 to 1945, showed that infrared absorption bands [1] are produced by groups of atoms rather than by single atoms and that each combination of atoms and each different physical arrangement of the same atoms in a substance or molecule would have a different infrared spectrum. As a result of this discovery, infrared spectroscopy became an important analytical tool in the chemical industries, but because of experimental difficulties the application of this method awaited the use of electronic systems.

When amplifiers were devised for use with infrared spectrometers in place of sensitive galvanometers, the uses for this new analytical tool grew rapidly. It is estimated that over 3,000 infrared spectrometers are presently in use for industrial applications. Meanwhile, development of the quantum theory gave great impetus to the use of infrared spectroscopy for the study of molecular structure. By considering the molecule as a small dynamical system, one can calculate the moments of inertia from the observed spectrum and can determine the distances between atoms and their spatial arrangement. Such infrared spectroscopic research is now being conducted in many laboratories throughout the world.

Since high-resolution spectrometers and new, precise measurement techniques have become available, Bureau scientists have been able to measure the spectra of many key molecules and to determine their molecular constants. Some of these molecules are methane, nitrous oxide, carbonyl sulfide, sulfur dioxide, acetylene, ethylene, ethane, and ammonia. Calculations [2] on the observed spectrum of methane have shown that the distance from the carbon atom to the hydrogen atoms is 1.093 A. In other work,[3] it was found that the C–H distance in ethylene is 1.086 A, the C–C distance is 1.337 A, and the angle HCH is 117°22″. For ethane,[4] a C–C distance of 1.534 A was obtained. Tidwell, Plyler, and Benedict [5] made a complete study of the nitrous oxide spectrum in which they found many bands that had not been observed previously. They were able to calculate from the spectrum a set of molecular constants which are the most complete set ever published for a triatomic molecule.

Much of the Bureau's effort has been devoted to the measurement of wavelengths, for until recently there were no adequate standards of wavelength for calibration in the infrared region. In 1955, Plyler and Blaine

E. K. Plyler and R. Thibault (right) operate the high-resolution grating spectrometer designed for use in the study of the absorption spectra of the vibrational-rotational bands of gases. The resolution of this instrument approaches 0.02 cm^{-1} in the wavelength region from 3 to 4 μ. With this spectrometer it is possible to resolve the vibrational-rotational bands of such heavy molecules as sulfur dioxide and nitric oxide and to determine their molecular structure.

made high-precision measurements of the spectrum of carbon monoxide. The wavelength values obtained are presently used as standards in many laboratories throughout the world. The results of this investigation were extended to a calculation of the velocity of light.[6] The value found is in excellent agreement with values arrived at by other methods.

The calibration of infrared spectrometers necessitates measurement of infrared bands of molecular spectra to a high level of accuracy. Widely used as standards for such calibrations[7] are the results obtained at the Bureau on the rotational-vibrational lines of nineteen bands which almost cover the spectral region from 2.5 to 16 μ. Nineteen of the twenty bands listed in *Tables of Wavenumbers for the Calibration of Infra-Red Spectrometers*[8] also were measured in the Bureau's infrared spectroscopy laboratory.

The Bureau has recently acquired some excellent equipment for studies of ionic molecules in crystal lattices at low temperatures. This equipment includes a dewar especially designed for spectroscopic observations on solids at temperatures down to 4 °K. A vacuum system is used to prepare gas mixtures which may be frozen on the sample window of the dewar for observation. Two spectrometers are used with this equipment: a prism instrument for low-resolution work, and a grating instrument for high-resolution work.

Infrared spectroscopic studies of various solids are being made with this arrangement at temperatures from 5 to 300 °K. An intensive study of the infrared spectrum of carbon monoxide has been completed. This compound was observed both in the pure solid state and as an impurity in solid argon, nitrogen, and methane matrices. Very precise measurements of the vibrational fundamental frequency for various isotopic carbon monoxide molecules in the solid state revealed a discrepancy between the observed frequencies and those calculated using the theory developed for a gaseous state.

Also under study are ionic molecules present in various types of crystal lattices. One such project involves cyanide ions held at negative ion sites in alkali halide crystals. Spectral changes which have been observed as the temperature is lowered are suggestive of a hindered rotation of the cyanide ion.

A study of the nitrate ion in various lattices, such as the calcite-type lattice of sodium nitrate and the aragonite structure of potassium nitrate, has shown some important ways in which the lattice affects the infrared spectrum. A detailed study of these two salts may elucidate the role played by crystal structure in the infrared spectra of solids.

The Bureau's plans for the present and the immediate future include further work on standard wavelengths, molecular spectra, and the measurement of ionic molecules in crystal lattices. At an early date, studies in the far infrared will be started using a Michelson-type interferometer, and a large grating spectrometer for the far infrared will be built. This instrument will be used to measure foreign gas broadening of the pure rotation spectra of gases. Other studies will be carried out on sources and detectors.

[1] Investigations of infrared spectra, *by W. W. Coblentz, Carnegie Institute (1907).*

[2] Band of methane, *by Harry C. Allen, Jr., and Earle K. Plyler, J. Chem. Phys.* **26,** *No. 4, 972–973 (1957).*

[3] The structure of ethylene from infrared spectra, *by Harry C. Allen, Jr., and Earle K. Plyler, J. Am. Chem. Soc.* **80,** *2673 (1958).*

[4] Ethane carbon-carbon distance obtained from infrared spectra, *by Harry C. Allen, Jr., and E. K. Plyler, J. Chem. Phys.* **31,** *No. 4, 1062–1065 (1959).*

[5] Vibration-rotation bands of N_2O, *by Eugene D. Tidwell, Earle K. Plyler, and W. S. Benedict, J. Opt. Soc. Am.* **50,** *No. 12, 1243–1263 (1960).*

[6] Velocity of light from the molecular constants of carbon monoxide, *by E. K. Plyler, L. R. Blaine, and W. S. Connor, J. Opt. Soc. Am.* **45,** *102 (1955)*; Velocity of light redetermined, *NBS Tech. News Bull.* **39,** *No. 1, p. 1 (1955).*

[7] Vibration-rotation structure in absorption bands for the calibration of spectrometers from 2 to 16 microns, *by Earle K. Plyler, Alfred Danti, L. R. Blaine, and E. D. Tidwell, NBS Mono. 16 (1960). For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price 20 cents.*

[8] Tables of wavenumbers for the calibration of infrared spectrometers, *compiled by the International Union of Pure and Applied Chemistry, Commission on Molecular Structure and Spectroscopy, (Butterworths, Washington, D.C., 1961).*

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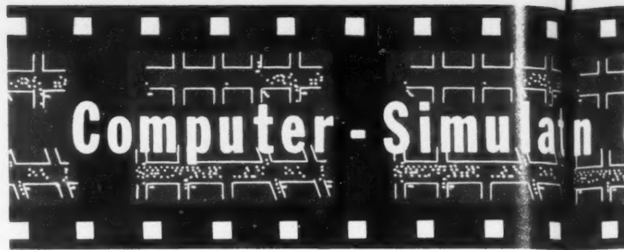


THE BUREAU has programed high-speed data processing and display equipment to simulate traffic flow over a nine-block length of a principal traffic artery in downtown Washington, D.C. After information on volume of traffic and traffic controls has been fed into the system, the simulated traffic flow is tabulated on printouts and is also shown in a motion picture of simulated cars moving, changing lanes, and stopping for lights, as in a helicopter view of the actual streets. This result has been attained in a three-year program[1] conducted by M. C. Stark of the data processing systems laboratory for the Bureau of Public Roads.

For some time the rapid increase of traffic on city streets has been a source of concern to traffic engineers and city planners. Municipalities must assume that streets now used to near capacity will have to carry even more traffic in the future. Thus traffic experts feel that detailed studies to correct congestion points—which even now are urgently needed—may become absolutely essential within perhaps the next decade. In such studies the problem is to determine the results of proposed changes in traffic control measures without actually disrupting traffic.

Automatic data processing to determine the optimum use, timing, and placement of traffic control devices appears to offer a promising approach to this problem. Simulation runs can be made with a computer to study the sensitivity of the traffic flow to proposed changes in the signal system and to explore the capacity of an existing system to handle different patterns or increased volumes of traffic. Many other traffic engineering situations—such as use of one-way streets, banning left turns, location of bus stops, and restriction of parking—also can be studied in this way.

Previous Work

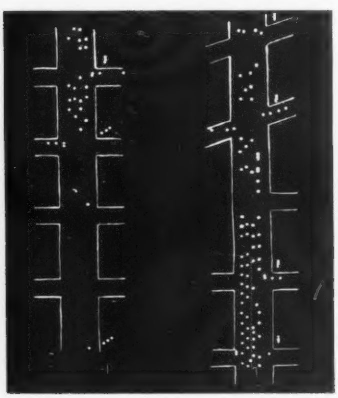
In 1956, H. H. Goode, of the University of Michigan, and his colleagues reported the use of computer techniques in traffic engineering[2] by setting up a computer model of two north-south and two east-west streets, both two-lane and two-way. All four intersections were signal-controlled and the route (straight through, right turn, or left turn) for each car was randomly assigned at each intersection. Each car was identical to all others and was represented by one binary digit or "bit;" all moved at the same speed and maintained the same spacing between cars. Traffic flow in the Goode model was presented in motion picture form for analysis.

Configuration of Model

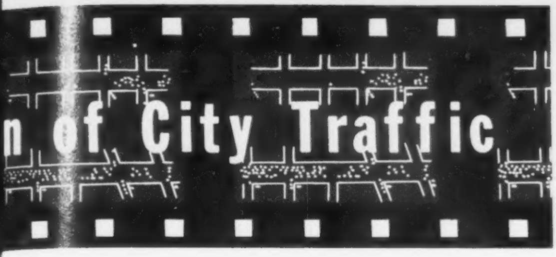
In 1958 the Bureau of Public Roads requested the National Bureau of Standards to conduct a traffic research study by means of a simulation model using several improvements over the earlier work as suggested by Professor Goode. The most significant improvement was the use of a computer "word" to permit the use of more variables and a planned route for each car instead of tabulating it as an undistinguished computer bit.

The model selected for use was based on a heavily traveled 0.6-mile stretch of Washington, D.C.'s 13th Street, N.W., which includes ten intersections from Euclid Street to Monroe Street. Seven of the intersections had traffic signals and three were controlled by stop signs at the east-west streets. The model includes several two-way cross streets (two at a 60° angle), one T-intersection, and several one-way cross streets. The study was restricted to the peak evening rush configuration in which all four lanes of 13th Street are used for northbound traffic.

Previously acquired traffic-survey information was used to determine the volume of cars traversing the entire course on 13th Street and those entering, crossing, and leaving it at each intermediate point. This permitted the computer program to show traffic composed of purposefully operated vehicles, each having a route assigned at the time of its generation.



Top of page: Motion picture shows simulated traffic flow obtained by means of computer techniques. Four frames of film were exposed following each ¼-sec computation cycle, resulting in a real-time presentation when projected at 16 frames per second. New computation takes place at center of strip shown. _Left:_ Single frame of motion picture shows traffic flow on maplike presentation. The course is photographed in two segments because of its shape, beginning at the lower left, the lower right continuing where the upper left ends, and ending at the upper right. Traffic lights are shown as a bar of three lights at northeast corners of some intersections. The vertical configuration indicates green for 13th Street traffic; horizontal, red, and diagonal, amber. The two lower traffic lights of the left-hand segment of 13th Street have just turned amber, the lower one is about to turn green for 13th Street traffic. The end of the platoon of cars just got through the middle light above on green, leaving only one car to be stopped for red. The green-light condition is continued for the entire upper half of the course, shown on the right. Single dots represent cars, double dots small trucks, and triple dots large trucks.



The streets of the model were divided up into 12-ft. long rectangles called "unit blocks." The unit blocks in each lane were numbered in sequence, from entrance to exit of the course and crosswise at each side street, so that any position could be given by unit block number. The computer required the position of each vehicle for each computation and assigned a new position (if changed) as part of each computation.

Operation of Model

Vehicles of the model were "generated" at each of the possible entrances to the course by means of random number generators in proportion to their numbers in the real course. At the same time each vehicle was assigned characteristics determining its route and behavior in traffic, also by means of random number generation and in numbers corresponding to the proportions in actual traffic. Most vehicles used 13th Street as an artery, being generated below the simulated stretch and leaving it at its northern end. Each vehicle destined for the end of the course continued at its desired speed unless forced to reduce speed for traffic signals and slower traffic in the same lane; each continued in its original lane unless forced to change to avoid being slowed by overtaken vehicles.

The vehicles generated at each entrance to the model were described by two words in digital format. Characteristics determined at "launch time" included: *Time of departure* in $\frac{1}{4}$-sec intervals; *type of vehicle*—automobile, small truck, or large truck; *exit* point to be used (determining the route); and *desired speed category*—15, 20, 25, 30, or 35 mph. All of these characteristics were chosen by means of random number selection from a series proportioned according to empirical knowledge.

Additional information was added within the vehicle two-word format as the computer surveyed the entire course at $\frac{1}{4}$-sec real time intervals. Its computations determined for each vehicle the length of its "jump," or distance traversed during an interval, and assigned to each its new *actual speed* and *position*, given by its unit block number and the hundredths of the block length to which the vehicle's nose had penetrated.

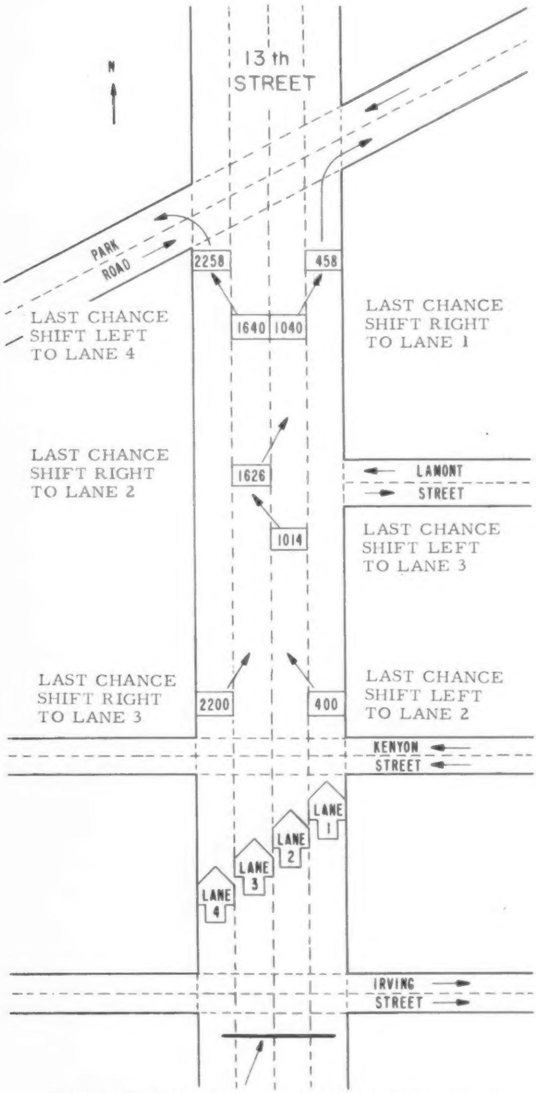
Vehicles approaching stopped vehicles in the same lane (where lane changing was not possible), a stop sign, or a red light were decelerated gradually; this took the form of $\frac{1}{4}$-sec jumps of decreasing size. A stopped vehicle was identified by its two-word digital description showing a zero jump and indicating the same position at successive intervals.

When the distance between any two vehicles in the same lane became less than the allowable net clear sight distance determined by both vehicles' speeds, the net clear sight distances for the overtaking vehicle in the two neighboring lanes were determined as part of the computations of each $\frac{1}{4}$-sec interval. The three alternatives (stay in lane, switch to right, or switch to left) were evaluated at each interval and the one chosen which best permitted the desired speed to be attained. The overtaking car was switched to the lane selected by being moved through progressive intermediate *straddle positions* during the time required to make the change. Vehicles obliged to stay in the same lane were gradually decelerated to the speed of the leading vehicle.

The routes assigned to vehicles at the time of generation determined their behavior in complex intersection situations. Westbound vehicles were not permitted to turn left (13th Street being one-way northbound) and hence could always proceed through or make a right turn in the lane determined by route or *lane preference* assigned at time of generation. Eastbound vehicles assigned a turn onto 13th Street were obliged to await a gap in west bound traffic. Those requiring a near or far lane because of a later turn waited to enter 13th Street on the appropriate lane. Those not assigned a later turn entered on the preferred lane (1 or 4), except for vehicles having a lane 4 preference, which if blocked by oncoming traffic went on to enter at Lane 1, waiting there to turn if necessary.

Preparing to make motion picture of oscilloscopic presentation of city traffic simulated by a computer. Martin C. Stark readies the Bureau's SEAC computer for operation, while in the foreground Leonard Cahn adjusts the oscilloscope on which the simulation is presented. The magnetic tape used as an input is obtained from a previous computer operation, which produces tabular printouts also. Camera is triggered for four frames following each computation cycle by means of solenoid beside it and circuitry below. When processed and projected at 16 frames per second the film presents the model operating in real time.

Vehicles were programed to prepare for turns assigned them by trying to get into the correct lane 1200 ft before arriving at the turn intersection. Map of part of Washington, D.C.'s 13th Street shows, for cars planning turns at Park Road (*top*), the start-preparation line (*bottom*). The numbers in the lanes are the course "unit block" numbers of the last-chance positions to make lane shifts in preparation for these turns. The left shift at UB 1014 is offset from the right shift at UB 1626 to avoid the possibility of a stalemate. Vehicles were programed to slow to a stop at the last-chance position if prevented by traffic from making a lane shift needed for their turn.



VEHICLES ASSIGNED A TURN AT PARK ROAD START GETTING IN APPROPRIATE LANE 1200 FEET AHEAD

Vehicles assigned a turn off of 13th Street were "coaxed" into the appropriate lanes when within 1,200 feet (100 unit blocks) of the turn. A definite pattern of "last chance" unit blocks for each lane shift approaching each intersection was programed into the computer. The cars made the necessary shifts in as rapid succession as possible when approaching the turning point, following the lane-switching rules.

Computer Operation

The computer operation was performed by first programing the "rules of the road" into a high-speed computer and "filling" the model course with vehicles in a pre-production run. Several computer runs, each of three complete 80-sec traffic light cycles (4 min), were made. Sixty minutes of computer time was needed to process each run because of the many computations required—as many as 500 (in the complex lane-changing situation)—for more than a hundred vehicles each $\frac{1}{4}$ sec.

A magnetic tape recording of the simulation and four tabular printouts were obtained from the computer; all were used in later analysis. One of the printouts, the *vehicle generation table,* gives for each vehicle the launch time, the exit, the type of vehicle (car, truck 1, truck 2, or marked vehicle), the generating point, the desired speed, and the lane preference. Another printout, the *station B check,* tabulates vehicles passing the maximum-load point of the course for comparison with empirical data. The third printout, the *vehicle retirement table,* tabulates the individual running times and actual speed of vehicles completing the course in each lane, also for comparison with empirical data. Finally, the *marked car chronological printout* gives the location of each marked car every $\frac{1}{4}$ sec for analysis of its progress.

The magnetic tape obtained from the computer was used to make a motion picture film of the simulated model in operation, resembling a helicopter view of traffic flow on the course. The tape supplied the input to the Bureau's SEAC computer, which operated an oscilloscope to produce a visual presentation of the computed vehicle movements. This presentation was retained for repetition and analysis by triggering a 16-mm motion picture camera, mounted in front of the oscilloscope, for four frames to depict the situation at the completion of each $\frac{1}{4}$-sec real-time computation. The processed film, when projected at 16 frames per second, shows the simulated traffic movement in the model for the 4-min run in real time.

Analysis of Results

Analysis of the tabular data and the film showed that the computer program caused the "vehicles" to behave in what seems to be a very realistic manner. They stopped at red lights, yielded right of way at stop signs, moved at various speeds, maneuvered for turns and to overtake slower cars, and formed queues when necessary; in short they did most of the definable things that are done by real cars in city traffic. During

runs of the model, vehicles actually came to a stop if they reached the last chance position without making the lane shift, just as seen occasionally in real traffic.

The simulation technique has produced a model which apparently can be made to correspond reasonably well with actual field situations. Thorough evaluation of the model will require new field data, as traffic on 13th Street has changed considerably since the original counts were made. When validated this technique will be useful in predicting the detailed effects on traffic flow due to changed parameters—moved or removed bus stops, altered signal light timing, and the like. Computer simulation will make possible experimental manipulation of traffic situations without the possibility of snarling the real traffic. Most important, experimental manipulation of traffic loads in models of today's streets should make it possible to estimate how long these streets can be used without change and to predict what changes will then be needed.

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[1] Computer simulation of street traffic, *by M. C. Stark, NBS Tech. Note 119.*

[2] The use of a digital computer to model a signalized intersection, *by H. H. Goode, C. H. Pollmar, and J. B. Wright, in Proc. Highway Research Board* **35**, *548–557 (1956).*

Two Technical Divisions Reorganized

Two of the Bureau's technical divisions, the Metallurgy Division and the Organic and Fibrous Materials Division, have been reorganized to further emphasize fundamental physical research in their areas. The Organic and Fibrous Materials Division has been renamed the Polymers Division.

The Metallurgy Division's program will give additional emphasis to fundamental work in physical metallurgy and to the interpretation of physical properties of metals in terms of their structure. Three new sections, Engineering Metallurgy headed by S. J. Rosenberg, Microscopy and Diffraction headed by H. C. Vacher, and Metal Reactions headed by G. A. Ellinger, have been added to the division. The Electrolysis and Metal Deposition Section headed by Abner Brenner, and the Metal Physics Section headed at present by Division Chief Lawrence M. Kushner will remain unchanged.

L. L. Wyman, former Chief of the old Chemical Metallurgy Section, has been named Consultant to the Division Chief and J. A. Bennett, former Chief of the old Mechanical Metallurgy Section, will devote full time to study of fatigue in metals.

The new Metal Reactions Section will conduct basic and applied investigations of reactions in metal systems, and between metals and their environments. It will also prepare experimental alloys and pure metals for the NBS standard samples program.

The Engineering Metallurgy Section will direct a program of basic and applied research on metals and metallurgical phenomena of technological importance; cooperate with other Government agencies in the investigation of service failures and toward the solution of specific metallurgical problems of vital importance to their programs; and operate service facilities for the melting, heat treatment, and fabrication of experimental alloys for use within the Bureau and other Government agencies.

The Microscopy and Diffraction Section will provide essential metallographic and X-ray diffraction services, conduct research on new metallographic techniques, and apply metallographic and diffraction techniques to the study of metallurgical phenomena.

The Polymers Division reorganization will provide better coordination and application of research work on the polymeric materials: rubber, textiles, paper, leather, and plastics. It has become increasingly evident in recent years that fundamental measurement programs on these materials are closely interrelated because of their common base—natural and synthetic organic macromolecules. G. M. Kline, Chief of the Division, has based the new sectional structure of the Division on technical objectives inherent in fulfilling responsibilities in the polymeric materials field in accordance with NBS statutory functions.

The Division will conduct experimental and theoretical research on the physical and chemical properties of polymers and the measurement processes involved. It will apply this competence in the development and maintenance of adequate measurement and materials standards, and will provide industry and government with essential services in this materials area.

Six sections, Macromolecules: Synthesis and Structure; Polymer Chemistry; Polymer Physics; Polymer Characterization; Polymer Evaluation and Testing; and Applied Polymer Standards and Research, have been established to carry out this mission. The Dental Research Section will remain unchanged.

In addition, the Division will have a consultant for each of the five major industrial types of polymeric materials:

Rubber	Dr. L. A. Wood
Textiles	Dr. H. F. Schiefer
Paper	Dr. R. B. Hobbs
Leather	Dr. J. R. Kanagy
Plastics	Dr. S. G. Weissberg

These consultants will continue to maintain close liaison and participation in the activities of standardization bodies, technical societies, and industrial organizations, and will provide leadership in the transfer of the fundamental information obtained in their respective fields.

Donald McIntyre has been named Chief of the Macromolecules: Synthesis and Structure Section. This section will study reactions, and fractionation and purification techniques leading to macromolecules of known molecular weight and microstructure. It will also conduct research on molecular structure, constants, and thermodynamic and transport properties of macromolecular systems and develop polymers of known molecular weight and structure to serve as standard samples.

The Polymer Chemistry Section, headed by Leo A. Wall, will study the reaction mechanisms and kinetics of polymerization and depolymerization; determine the chemical changes that occur when polymers are subjected to various environmental influences such as heat, ultraviolet light, and atomic radiation; and investigate the role of chemical structure, impurities, thermodynamics, and energetic factors on the stability of polymers.

Elio Passaglia has been named Chief of the Polymer Physics Section. He will direct a research program of measurements of the mechanical, electrical, thermal, and optical properties of polymers, with the objective on interpreting their physical behavior on a molecular basis. The section will also investigate the effects of static and dynamic forces and time factor on the physical reactions of polymers, and will measure thermodynamic properties associated with the crystalline, semicrystalline, and amorphous states of polymers.

Norman Bekkedahl, who was Chief of the former Polymer Structure Section, will direct the Polymer Characterization Section. This section will develop, adapt, and apply procedures and instrumentation for the determination of the chemical structure, steric relationships, and morphological characteristics

of polymers. It will also develop methods for the separation, purification, identification, and quantitative analysis of polymeric materials, and will investigate the chemical reactivities and interactions of functional groups in polymers.

Chief of the Polymer Evaluation and Testing Section is Robert D. Stiehler, formerly Chief of the Testing and Specifications Section. He will direct the physical and chemical testing of rubber, textiles, paper, leather, plastics, and other organic materials for Federal and State agencies, and cooperate with other Government agencies in the evaluation of performance characteristics of polymeric products of vital importance to their programs. The section will also develop and maintain standard samples for calibration of testing procedures for polymeric materials.

Robert B. Hobbs, formerly Chief of the Paper Section, is Chief of the Applied Polymer Standards and Research Section. The section will cooperate in measurement and standardization activities with industry, technical societies, Government agencies, and national and international standardization bodies, develop test methods for the determination of basic physical, chemical, and engineering properties of polymeric materials, and provide research services to other Government agencies on the development and specification of polymeric materials to meet special requirements.

A.O.A.'s Standards and Metrology Division Meets at NBS

THE 17th ANNUAL meeting of the Standards and Metrology Division of the American Ordnance Association was held at the Bureau Wednesday and Thursday, February 14 and 15, 1962. Over 100 delegates from industry, government, and the military were in attendance at the meeting, the central theme of which was "Practical Aspects of Standards."

The meeting was opened by H. Curtis Biggs, Chairman of the Standards and Metrology Division, followed by an address of welcome by Dr. A. V. Astin, Director, NBS. Then J. R. Townsend, President of the American Standards Association, discussed "Engineering Standards" throughout the world. He pointed out the continuing need for new and improved standards—standards of measurement and of means of accomplishing a given purpose—in modern technology, and commented on the opportunity the United States has to aid technologically underdeveloped nations through the provision of standards and standard techniques.

Martin A. Mason, Dean of the George Washington University School of Engineering, outlined the criteria on which the training of measurement technicians and of metrologists is based, and briefly described the program of the GWU Institute of Measurement Science.[1] James A. Davis, Deputy Assistant Secretary of Defense, discussed the impact of measurement problems on the cost of national defense. He indicated that a partial solution to the problem lies in increased communication between the agencies involved, and in clearly defining the responsibilities of the various groups.

Dr. Astin presented a talk on the "Mechanism of the International Unified System." He traced the development of our present systems of measurement and standardization, and noted the increased measurement competence resulting from the current practice of interchanging personnel among the various standards laboratories. Lloyd B. Wilson of Sperry Gyroscope's Electrical Measurements Laboratory reported on "Evaluative Criteria for Corporate and Company Standards Laboratories," and Col. O. C. Griffith, USAF, described the "Air Force Primary Standards Laboratories."

Wednesday afternoon was devoted to workshop sessions. The attendees split into three groups—concerned with dimensional, electronic, and physical problems—and considered various aspects of these particular areas. At a banquet held Wednesday evening the A.O.A. Gold Medal Award was presented Dr. Astin (see p. 81). Adm. A. G. Noble, Vice President of A.O.A., served as master of ceremonies, and J. E. Trainer, President of the American Ordnance Association, was the principal speaker at the dinner.

On Thursday morning the chairmen of the individual workshop sessions summarized the activities of their groups for the membership as a whole. The meeting was then closed by a general summary, followed by a tour of the NBS facilities.

***Top of page:* Delegates to the meeting of the Standards and Metrology Division of the A.O.A. toured the Bureau Laboratories. T. Lawrence (*far left*) of the Bureau's Engineering Metrology Section explains the operation of the helium-neon laser (glowing horizontal tube).**

[1] NBS to cooperate in new institute of measurement science, *NBS Tech. News Bull.* **44,** 212 (Dec. 1960).

A.O.A. Gold Medal Presented to A. V. Astin

Dr. A. V. Astin, NBS Director, was presented the American Ordnance Association's Gold Medal Award for distinguished service in support of defense industrial mobilization programs. The award, named for Colonel Frank A. Scott, a founder of the A.O.A., was given to Dr. Astin on February 14, 1962 in recognition of his "contribution to technical progress in many fields, including ordnance development." H. N. Marsh, Vice President for A.O.A. Technical Divisions and Sections, makes the award, while J. E. Trainer, President, A.O.A., looks on.

IRE PGMTT to Hold 1962 National Symposium at NBS Boulder Laboratories

The 1962 National Symposium of the Institute of Radio Engineers' Professional Group on Microwave Theory and Techniques (PGMTT), to be held May 22–24 at the National Bureau of Standards' Laboratories in Boulder, is expected to attract some 500 scientists and engineers.

During the three-day symposium 37 papers will be presented in ten technical sessions: Microwave Frontiers; Theory, Waveguide Properties; Theory, Waveguide Discontinuities; Filters; High Power; Measurements; Components; Limiters; Parametric Amplifiers; Future of Microwave and Solid State.

Highlighting this tenth anniversary of the PGMTT will be a keynote address by Dr. John M. Richardson of the NBS Radio Standards Laboratory, and a banquet speech by microwave pioneer Dr. W. L. Barrow on "Reminiscences of a Microwaver." The program will include a visit to the U.S. Air Force Academy at Colorado Springs.

Session chairmen for the Symposium are: Dr. Donald D. King, Electronic Communications, Inc.; Prof. Arthur A. Oliner, Polytechnic Institute of Brooklyn; Dr. Seymour B. Cohn, Rantec Corporation; R. W. Beatty, National Bureau of Standards; M. T. Lebenbaum, Airborne Instruments Laboratory; and Dr. Kiyo Tomiyasu, General Electric Company.

Professor George Schafer, North Carolina State College, is Chairman of the 1962 Symposium and Mr. Beatty is Chairman of the Technical Program Committee. Other members of the 1962 Symposium Committee (all from the National Bureau of Standards) are: James F. Brockman, Secretary and Chairman of Local Arrangements Committee; John L. Dalke, Chairman of Publicity Committee; and Dr. Moody C. Thompson, Chairman of Finance Committee.

An advance program, including abstracts of all the papers and advance registration forms, may be obtained from Mrs. Barbara Patterson, 1962 PGMTT National Symposium, Boulder Laboratories, National Bureau of Standards, Boulder, Colorado.

Rapid Method for Predicting

ASPHALT DURABILITY

NBS RESEARCH on the properties of materials has resulted in a rapid, reproducible method for predicting the durability of roofing asphalts. In this method, infrared spectroscopy is used to determine the oxidation rates of thin film specimens; these rates then provide an accurate measure of asphalt durability.[1] Thus, data that would require weeks to obtain by the usual accelerated weathering techniques[2] can now be obtained in a few hours. The rapid method, devised by James R. Wright and Paul G. Campbell of the organic building materials laboratory, should be of particular value in developing improved specifications for asphalt roofing materials.

A fast, dependable method has long been sought for measuring asphalt degradation from weather exposure. The usual laboratory method consists of exposing 25-mil thick specimens to accelerated weathering conditions until failure occurs.[3] While the agreement between results obtained in this manner and those of actual outdoor exposure tests is generally very good, the time required for such laboratory testing is still time-consuming.

Experimental Study

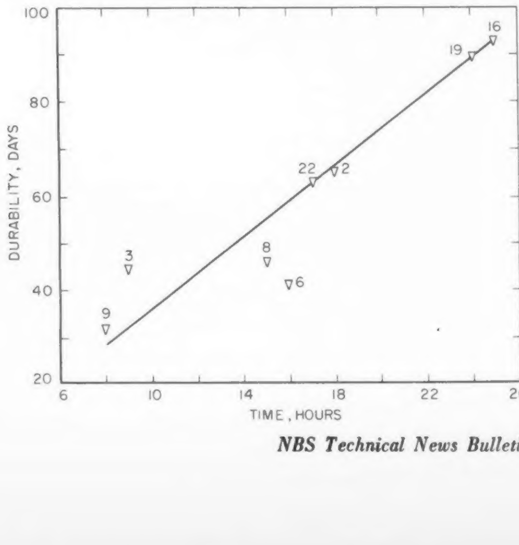
The rapid prediction method is based on a study of eight roofing asphalts with known durabilities, and procured from four different sources—California, Southeastern United States, Venezuela, and Central United States. They were made into thin film specimens by pressing cold vacuum-dried pellets, about 4 mm in diameter, between sheets of unlacquered cellophane in a hydraulic press heated to 250 °F. After film thickness ($25 \pm 2\mu$) was measured, suitable exposure areas of about 1.50 cm^2 were mapped, and the films were separated from the cellophane by soaking in distilled water. They were mounted on specimen holders, dried overnight at ambient temperature, and then scanned in an infrared spectrophotometer. In the resulting spectra, the strongest absorbance, other than carbon-hydrogen, occurred in the carbonyl band at the 5.88-μ wavelength.

The specimens were irradiated by exposure to a carbon arc at 120 °F and 40 percent relative humidity for selected periods, after which they were rescanned in the spectrophotometer to detect chemical changes. The increased absorbance found at the 5.88-μ wavelength, caused by the carbon arc radiation, was used to determine the oxidation rates of the specimens. This increase, defined as the carbonyl index value, was readily calculated from the difference in the two spectra obtained from each specimen.

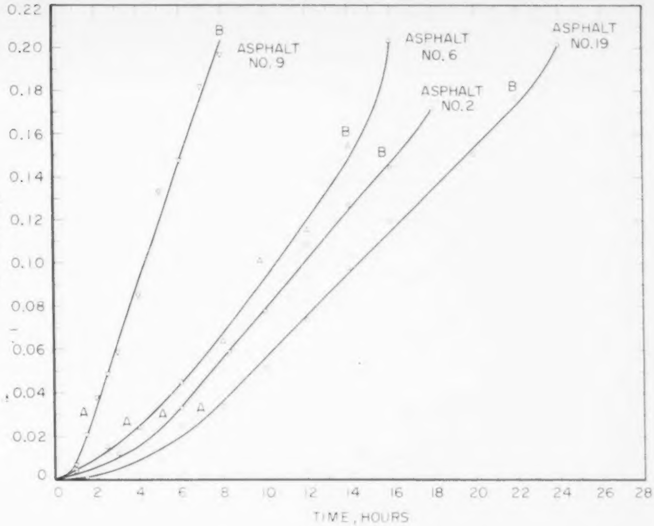
Results

Data obtained in the form of carbonyl index values were plotted against time lapse to find the oxidation rates. The resulting curves emphasized the marked differences in these rates, confirming previous findings, with time to failure varying from 8 to 25 hr. Each asphalt went through an induction period and then oxidized at a steady rate. Finally, several of the more durable specimens in the last 2 hr of exposure showed an accelerated oxidation rate. The curves indicated

Below: Relationship found between asphalt durability as determined by an accelerated weathering method and the time to failure of specimens exposed to carbon arc radiation. The specimens numbered 9 and 3 were from California; 8 and 6 from Southeastern United States; 22 and 2 from Venezuela; 19 and 16 from Central United States. *Left:* The oxidation rate of an asphalt specimen is determined after it has been scanned in an infrared spectrophotometer, exposed to carbon arc radiation, and then rescanned in the spectrophotometer. P. G. Campbell removes a specimen from the instrument after rescanning.



Oxidation-rate data obtained in a study of roofing asphalts from different geographic areas. These data are expressed as carbonyl index values versus time of exposure to carbon arc radiation. The A–B portion of each curve represents a steady oxidation rate. Asphalt No. 9 came from California; No. 6 from Southeastern United States; No. 2 from Venezuela; and No. 19 from Central United States.



the length of the induction period, the time period of steady oxidation rate, and the time that expired just prior to film failure.

A straight-line correlation was obtained when asphalt durability as determined by accelerated weathering techniques was plotted against the time required to produce film failure by carbon arc radiation. Such a correlation is particularly significant because failure presumably results not only from oxidation but from other processes as well, such as polymerization, dehydrogenation, volatilization, and migration of the oil phase.

The relationship found in this study between carbonyl index values, film-failure time, and asphalt durability demonstrates the value of oxidation rate data as a means of predicting accelerated weathering durability. It is anticipated that the use of the infrared spectroscopic technique for obtaining these data may assist in the upgrading of inferior asphalts and in improving the more durable ones.

[1] *For further technical details, see* Determination of oxidation rates of air-blown asphalts by infrared spectroscopy, *by James R. Wright and Paul G. Campbell, Div. Petroleum Chem. (ACS) preprint, Mar. 1962; also, J. of App. Chem. (London) in press.*

[2] A statistical study of weather-ometer data on coating-grade asphalts, *by S. H. Greenfeld, E. W. Mertens, and P. W. M. John, ASTM Spec. Tech. Publ. No.* **280,** *29 (1959).*

[3] Accelerated tests of asphalts, *by O. G. Strieter, J. Research NBS* **5,** *247 (1930).*

1962 STANDARDS LABORATORY CONFERENCE

The 1962 Standards Laboratory Conference sponsored by the National Conference of Standards Laboratories will be held August 8, 9, and 10 at the NBS Boulder, Colo., Laboratories.

The purpose of this Conference is to provide a medium for disseminating information on the organization and operation of standards laboratories with the goal of promoting increased competence, better organization, and uniform practices among standards laboratories throughout the nation. This will complement the 1962 International Conference on Precision Electromagnetic Measurements, covering the technical aspects of standards and accurate measurement, to be held at the Boulder Laboratories during the following week on August 14, 15, and 16, 1962. Chairmen of the Standards Laboratory Conference will be: Allen V. Astin, Director, NBS, General Chairman; Charles Johnson, The Boeing Co., Program Chairman; Harvey Lance, NBS, Arrangements Chairman.

Conference Sessions

(1) National Bureau of Standards Services to Industry
Session Developer: William A. Wildhack, NBS

(2) Measurement Agreement Among Standardizing Laboratories
Session Developer: S. C. Richardson, General Electric Company

(3) Error Analysis of Measurement Systems
Session Developer: Leon W. Bowen, the Boeing Company

(4) Corporate Standards Laboratories
Session Developer: L. R. Wallace, International Business Machines

(5) Calibration Procedures
Session Developer: Peter Joeschke, Autonetics

(6) Calibration Recycle Analysis and Workload Control
Session Developer: J. L. Hayes, Bureau of Naval Weapons

(7) Training of Measurement Personnel
Session Developer: A. J. Woodington, General Dynamics/Astronautics

(8) Recommended Practices for Standardizing Laboratories
Session Developer: K. G. Overbury, Sandia Corporation

For further Conference details, including registration forms (available about June 1), contact Alfred E. Hess, Circuit Standards Division, National Bureau of Standards, Boulder, Colorado.

Publications of the National Bureau of Standards

Periodicals

Technical News Bulletin, Vol. **46,** No. 4, Apr. 1962. 15 cents. Annual subscription: \$1.50; 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Basic Radio Propagation Predictions for July 1962. Three months in advance. CRPL-212, issued April 1962. 15 cents. Annual subscription: \$1.50; 50 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, \$4; foreign, \$4.75.

Section B. Mathematics and Mathematical Physics. Issued quarterly. Annual subscription: Domestic, \$2.25; foreign, \$2.75.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, \$2.25; foreign, \$2.75.

Section D. Radio Propagation. Issued six times a year. Annual subscription: Domestic, \$4; foreign, \$4.75.

Nonperiodicals

Standard X-ray diffraction powder patterns. H. E. Swanson, M. C. Morris, R. P. Stinchfield, and E. H. Evans, NBS Mono. 25—Section 1 (Mar. 9, 1962) 40 cents.

Theory and methods of optical pyrometry, H. J. Kostkowski and R. D. Lee, NBS Mono. 41 (Mar. 1, 1962) 25 cents.

Standard materials issued by the National Bureau of Standards. A descriptive list with prices, NBS Misc. Publ. 241 (Mar. 12, 1962) Supersedes C 552, 3d edition, 30 cents.

Technical Notes

The following Technical Notes are available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. (Order by PB number).

A transistor-magnetic core digital circuit, E. W. Hogue, NBS Tech. Note 113 (PB 161614) (1961) \$3.00.

Provisional thermodynamic functions for para-hydrogen, H. M. Roder and R. D. Goodwin, NBS Tech. Note 130 (PB161631) (1961) \$3.00.

Photoionization of atoms and molecules, F. L. Mohler, NBS Tech. Note 131 (PB161632) (1962) \$1.25.

Evaluation of convolution integrals occurring in the theory of mixed path propagation, J. R. Johler and C. M. Lilley, NBS Tech. Note 132 (PB161633) (1961) \$1.00.

Historical survey of fading at medium high radio frequencies, R. K. Salaman, NBS Tech. Note 133 (PB161634) (1962) 75 cents.

Publications in Other Journals

Comparison of United States and Canadian free-air ionization chambers, J. H. Aitken, L. De LaVergne, W. H. Henry, and T. P. Loftus, Brit. J. Radiol. **35,** No. 409, 65–70 (Jan. 1962).

Statistical problems arising in the establishment of physical standards, W. J. Youden, Proc. Fourth Berkeley Symp. on Math. Statistics and Probability III, 321–335 (1961).

Analysis of the absorption spectrum of $YbCl_3 \cdot 6H_2O$, J. C. Eisenstein, J. Chem. Phys. **35,** No. 6, 2097–2100 (Dec. 1961).

A lattice with an unusual frequency spectrum, R. J. Rubin and R. Zwanzig, J. Math. Phys. **2,** No. 6, 861–864 (Nov.-Dec. 1961).

National Bureau of Standards, Washington, D.C., and Boulder, Colorado, C. E. Moore, Astron. J. **66,** No. 10 (Dec. 1961).

Rapid method for interpolating refractive index measurements, O. N. Stavroudis and L. E. Sutton, J. Opt. Soc. Am. **51,** No. 3, 368–370 (Mar. 1961).

The three-dimensional nature of boundary-layer instability, P. S. Klebanoff, K. D. Tidstrom, and L. M. Sargent, J. Fluid. Mechanics **12,** Pt. 1, 1–34 (1962).

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